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PATENT & TRADEMARK OFFICE

PATENT APPLICATION
ATTORNEY DOCKET NO. 10007137-1

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

ART UNIT: 2655 EXAMINER: Nabil Z. Hindi APPLICANT: Gibson et al. SERIAL NO.: 09/865,940 FILED: May 25, 2001 CONFRM. NO.: 6644 FOR: DATA STORAGE MEDIA UTILIZING DIRECTED LIGHT BEAM AND NEAR-FIELD OPTICAL SOURCES	**RESPONSE/AMENDMENT** **CERTIFICATE OF MAILING UNDER 37 C.F.R. § 1.8** DATE OF DEPOSIT: January 31, 2005 I hereby certify that this paper or fee (along with any paper or fee referred to as being attached or enclosed) is being deposited with the United States Postal Service with sufficient postage as first class mail on the date indicated above and is addressed to: Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450. **Vaughn W. North**

DECLARATION OF ALISON CHAIKEN
UNDER 37 C.F.R. § 1.131

Commissioner for Patents
P.O. Box 1450
Arlington, VA 22313-1450

I, Alison Chaiken, declare as follows:

1. I am a named co-inventor in the above-captioned application and of the subject matter described and claimed therein.

2. It is my understanding that the claims in the above-recited patent application have been rejected in view of U.S. Patent No. 6,473,388 filed August 31, 2000 and issued to Gary A. Gibson, on October 29, 2002 (hereinafter the Gibson 388 Patent).

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3. The invention as described and claimed in the above-reference patent application, Serial No. 09/865,940, filed May 25, 2001, entitled: "Data Storage Media Utilizing Directed Light Beam and Near-Field Optical Sources," ("Present Application") was conceived and reduced to practice by the inventors named therein prior to August 31, 2000.

4. Exhibit 1, attached hereto and dated June 27, 2000, is a set of slides used in a presentation that I gave that contains information about a reduction to practice of the invention in the Present Application. Slide 13 in Exhibit 1 shows some bits recorded in a phase-change material (In2Se3) using a laser light beam. The image was created in connection with the photoconductive readback structure that is one of the embodiments shown in the Present Application.

5. The presentation slides shown in Exhibit 1 are evidence of conception and reduction to practice of the invention in the Present Application prior to August 31, 2000, particularly with respect to the photoconductive readback embodiment shown therein.

6. Exhibit 2, attached hereto and dated August 30, 2000, is a copy of an invention disclosure that I and the other inventor in the Present Application, Gary A. Gibson, prepared and submitted to our employer, Hewlett Packard.

7. The document in Exhibit 2 is further evidence of conception and reduction to practice of the invention in the Present Application prior to August 31, 2000.

8. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful, false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States

Code, and that such willful, false statement may jeopardize the validity of the application or any patent issuing thereon.

Declared this 21st day of December, 2004.

Alison Chaiken

<u>Exhibit 1 to Declaration of Alison Chaiken</u>

Media Writing Experiments and Electrical Characterization

Alison Chaiken
Advanced Storage Department
June 27, 2000

- Electrical experiments: good transport properties in In_2Se_3
- Writing experiments: problems, success?
- Looking ahead to cyclability challenge

Purpose of Transport Experiments

- Track media film quality
- Select devices for more sophisticated measurements
- Provide parameters for device modeling
- 3 types of experiments:
  - Hall to measure carrier density, mobility
  - AC photoconductivity to measure frequency response
  - DC photocurrent to measure device performance.

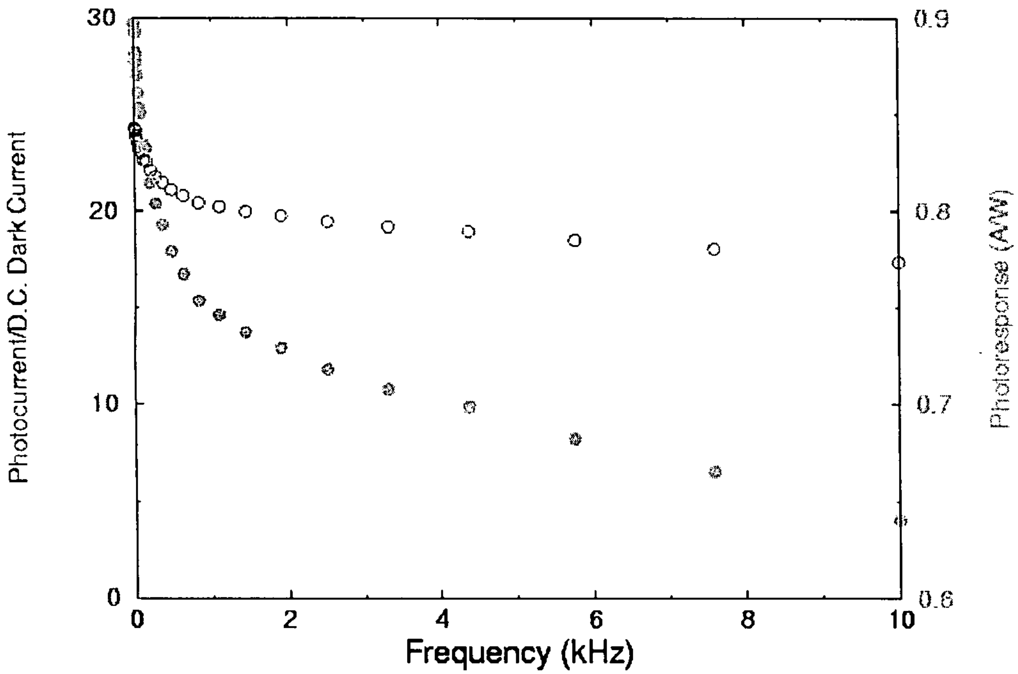
First Successful Hall Measurements on In_2Se_3

- Mobilities in the range 10 to 40 cm^2/V-s.
- Carrier densities 10^{12} to 10^{14} cm^{-3}, always n-type.
- Resistivities in the range of 10^3 to 10^5 ohm-cm:
  - may be too resistive for diodes;
  - good range for cathodoconductivity devices;
  - doping may lower resistivity (Te addition experiments).
- Correlation with deposition parameters is weak.

hp invent

Large Photoeffect in In_2Se_3

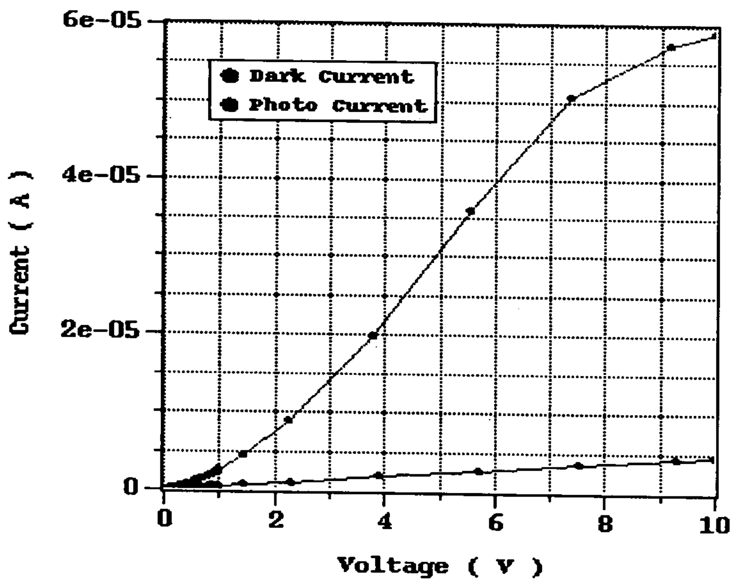
In_2Se_3 cathodoconductivity device



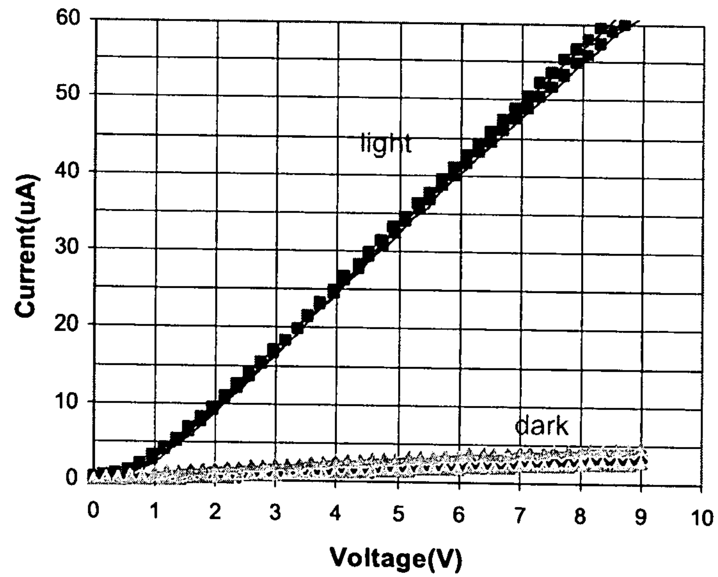
- Frequency dependence and magnitude indicate electronic origin.
- Predict large cathodoconductivity response.
- U. Nantes reports larger photoconductivity in Te-doped In_2Se_3 than in undoped In_2Se_3.

Modeling will help predict device performance

Model



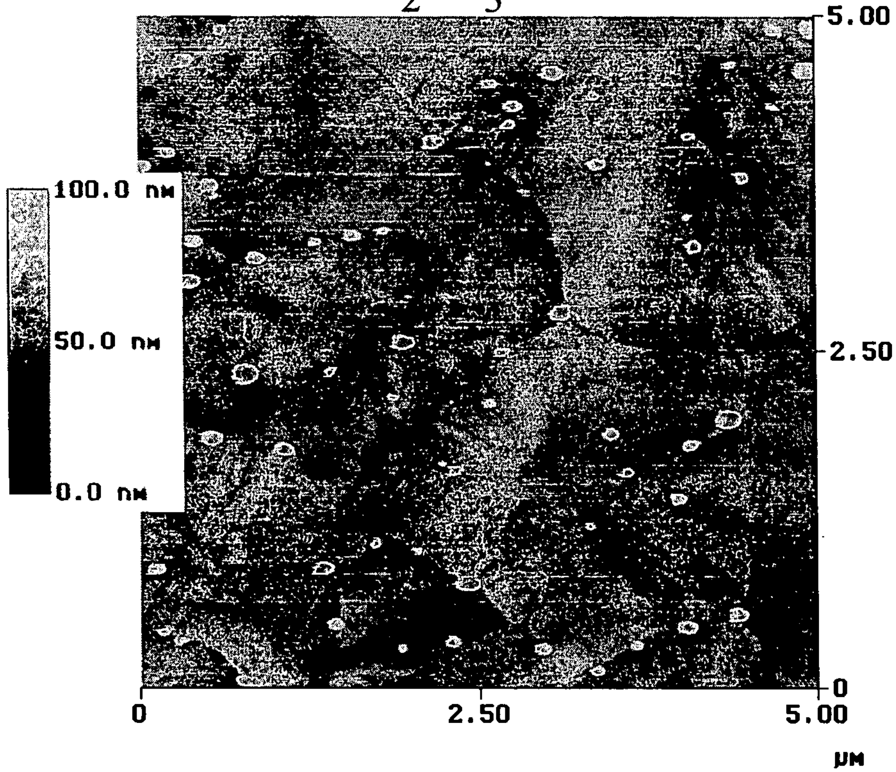
Experiment



Courtesy Bao Yeh, ITP

Grain size and transport properties

In_2Se_3/Si



- Hall devices are on SiO_2.
- Films have <= 100 nm grain size.
- Films on Si can have >=1µm grain size.
- Media films on diodes have better properties?

Enlarge grain size by annealing?

- AFM shows post-annealing films does not enlarge grain size;
  - needs quantitative x-ray study.
- Hall devices consistently more resistive after annealing in inert atmosphere, even capped films.
  - Films become more intrinsic?
  - Se loss at grain boundaries?
  - Oxidation at grain boundaries?

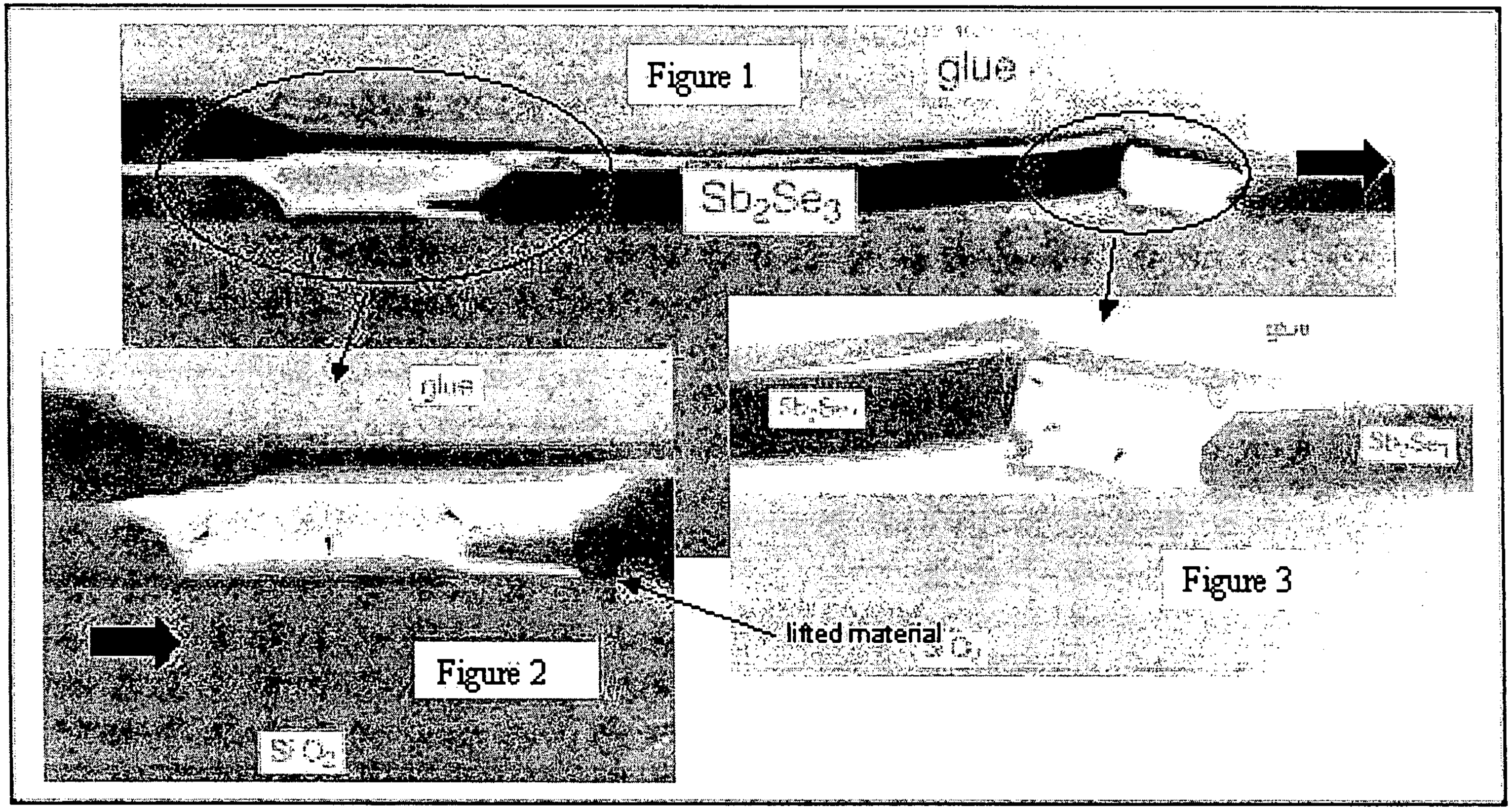
Grain size and transport properties

- Film electrical properties may be dominated by space-charge regions at grain boundaries.
- Grain boundary engineering an essential part of making devices work.
- New experiments:
  - Se cap layer to discourage composition changes;
  - hydrogen plasma annealing to passivate dangling bonds.

Writing Amorphous Marks on In_2Se_3 Media

- In some sense, a trivial task.
- However, problems may arise:
  - delamination of film from substrate or cracking;
  - decomposition or oxidation of In_2Se_3;
  - diffusion of excess Se;
  - sublimation at a temperature below melting.
- Reliably identifying the amorphous phase is another problem.

Writing Amorphous Spots on Sb2Se3 Successful



Courtesy of Chris Nauka and LBNL

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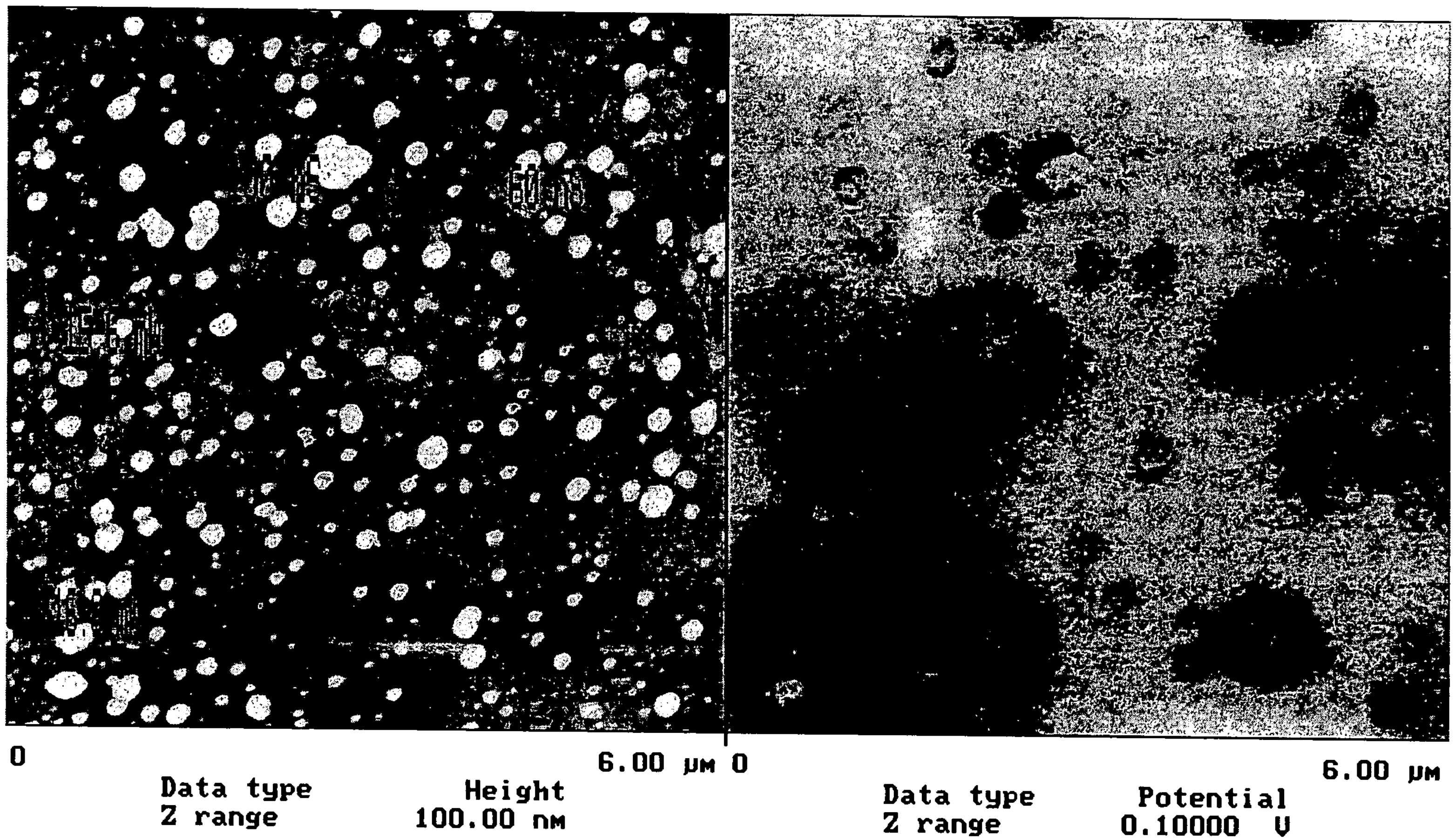
invent

Marking Films -- or Destroying Them?

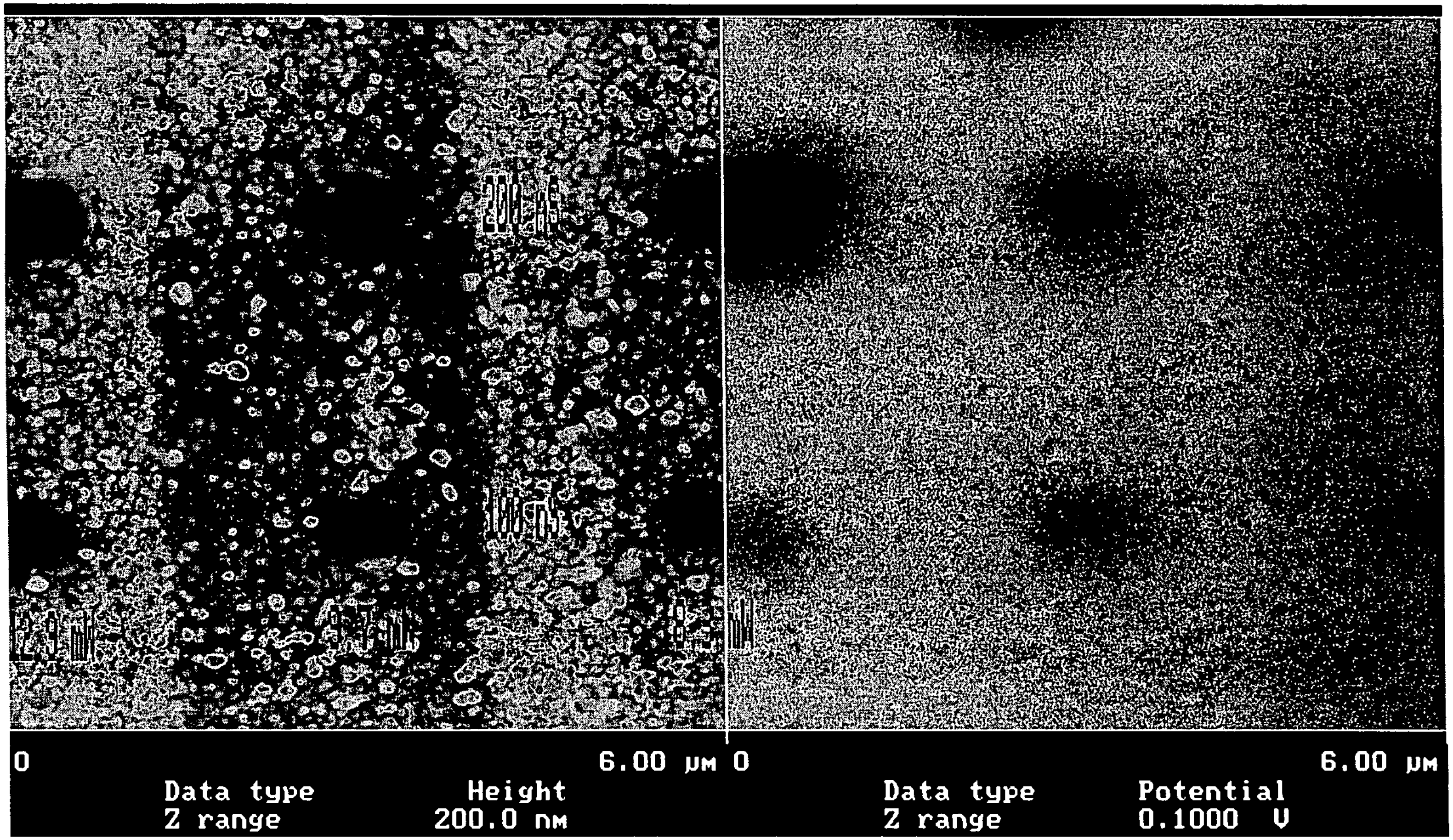
170 nm thick In_2Se_3 with μm-scale grains on Si



TEM so far inconclusive.

Small-grained films survive marking better

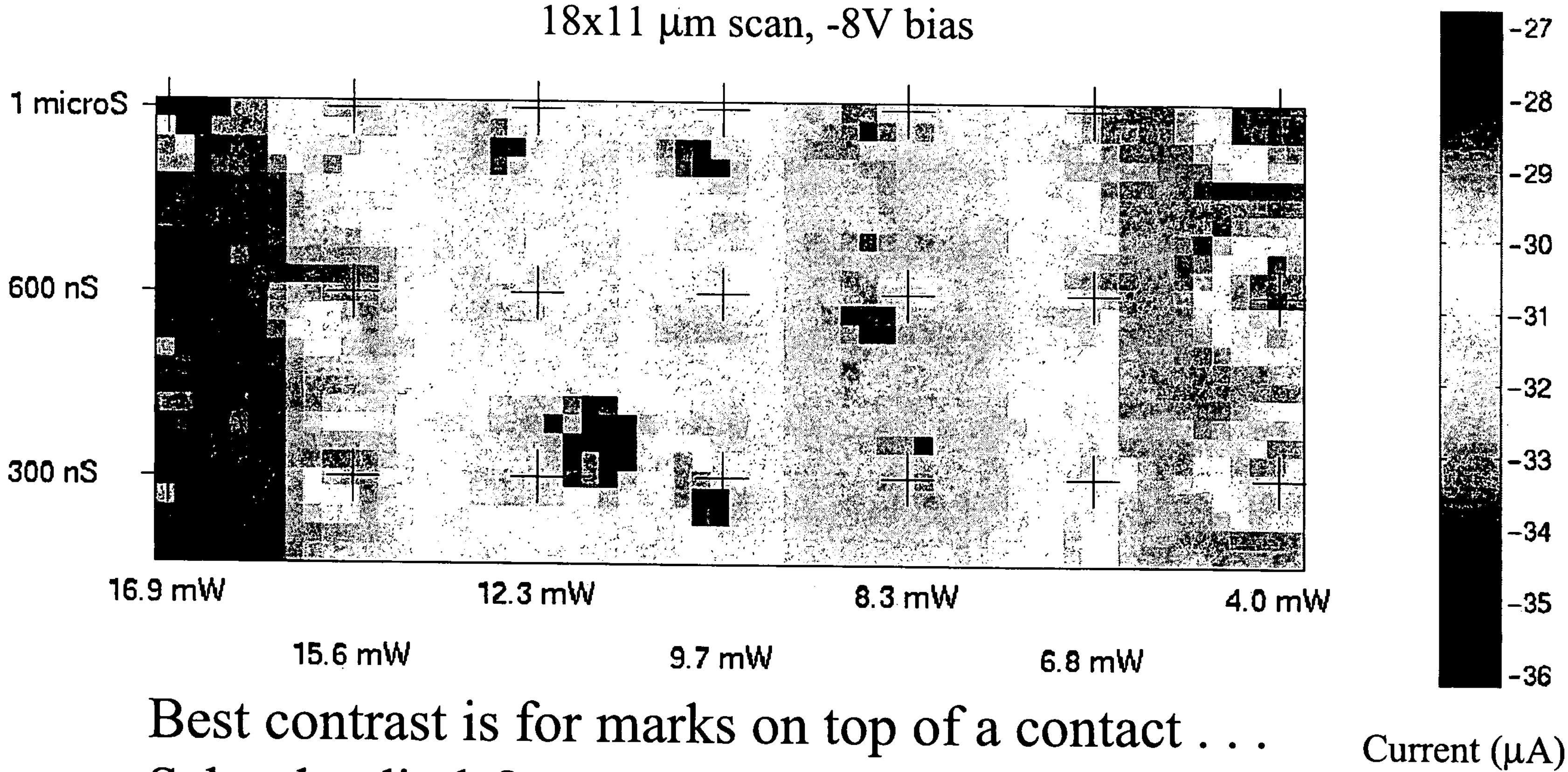
400 nm thick In_2Se_3 with 100 nm grains on SiO_2



Thanks to G. Burward for improved sample fixturing.

Lasers Marks are Visible in Photocurrent Image

18x11 μm scan, -8V bias

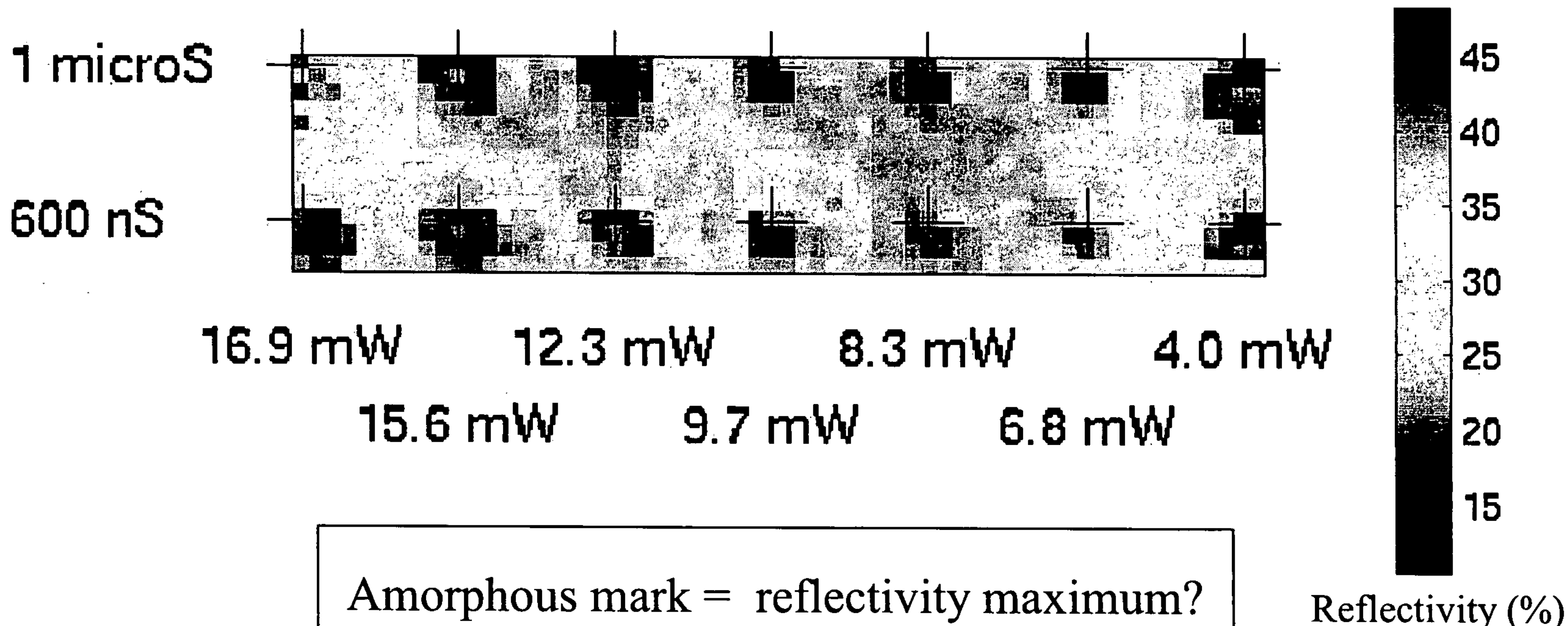


Best contrast is for marks on top of a contact . . . Schottky diode?

Optical system built by Henryk Birecki.

Plenty of Questions Remain

18x4 μm Reflectivity Image



Amorphous mark = reflectivity maximum?

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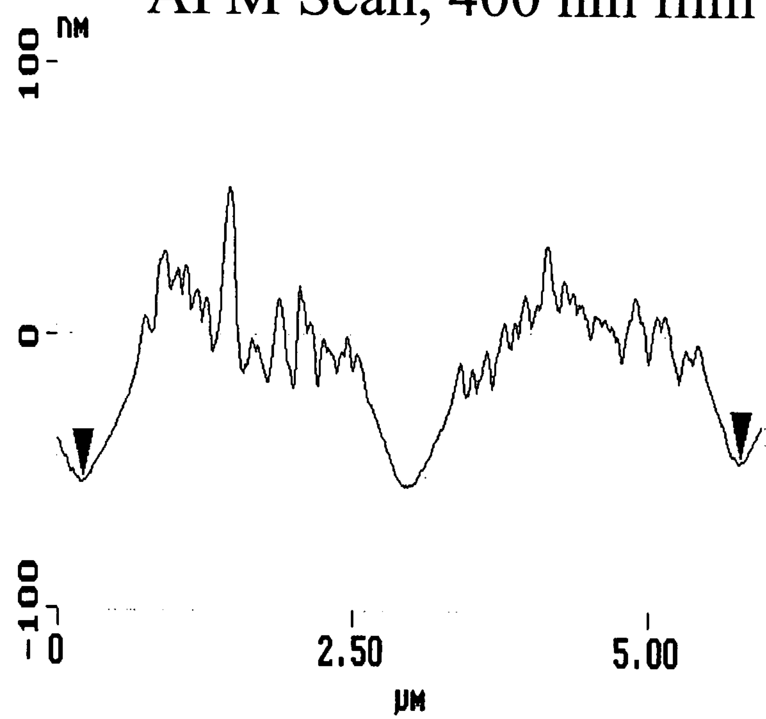
Plenty of Questions Remain

- Marks are noticeably smoother than background.
- In In_2Se_3, laser marks are always depressions.
- Absorption length of 488 nm light about 40 nm, similar to depth of depressions.

AFM Scan, 400 nm film



Future Work

- Correlate grain size and film texture to transport properties. (Y. Matsushita, SEED)
- Work with ITP to determine whether writing causes compositional changes.
- Work with Gary Ashton and Mauricio Huerta (MSB) to improve laser tester.
- Begin overwrite studies.
- Write amorphous marks on diodes.

Conclusions

- AFM, optical studies suggest amorphous spot writing has been achieved.
- Successful readback of laser marks on cathodoconductivity device.
- Transport properties of In_2Se_3 films are encouraging, possibly good enough.
- Cyclability remains an open question.

Exhibit 2 to Declaration of Alison Chaiken

HEWLETT PACKARD **INVENTION DISCLOSURE** 9/12/00 PAGE ONE OF 4

PDNO 10007137 DATE RCVD ATTORNEY THD

*Instructions: The information contained in this document is **COMPANY CONFIDENTIAL** and may not be disclosed to others without prior authorization. Submit this disclosure to the HP Legal Department as soon as possible. No patent protection is possible until a patent application is authorized, prepared, and submitted to the Government.*

Descriptive Title of Invention:
Data Storage Medium Utilizing Near-Field Optical Source

Name of Project:
Atomic Resolution Storage

Product Name or Number:

Was a description of the invention published, or are you planning to publish? If so, the date(s) and publication(s):
No.

Was a product including the invention announced, offered for sale, sold, or is such activity proposed? If so, the date(s) and location(s):
No.

Was the invention disclosed to anyone outside of HP, or will such disclosure occur? If so, the date(s) and name(s):
No.

If any of the above situations will occur within 3 months, call your IP attorney or the Legal Department now at 1-898-4919 or 970-898-4919.

Was the invention described in a lab book or other record? If so, please identify (lab book #, etc.)

Yes. Lab book #1814.

Was the invention built or tested? If so, the date:

No.

Was this invention made under a government contract? If so, the agency and contract number:

No.

Description of Invention: *Please preserve all records of the invention and attach additional pages for the following. Each additional page should be signed and dated by the inventor(s) and witness(es).*

A. Prior solutions and their disadvantages (if available, attach copies of product literature, technical articles, patents, etc.).
B. Problems solved by the invention.
C. Advantages of the invention over what has been done before.
D. Description of the construction and operation of the invention (include appropriate schematic, block, & timing diagrams; drawings; samples; graphs; flowcharts; computer listings; test results; etc.)

Signature of Inventor(s): Pursuant to my (our) employment agreement, I (we) submit this disclosure on this date: [August 30, 2000].

Employee No.	Name	Signature	Telnet	Mailstop	Entity Acronym
268872	Gary Gibson	Gary Gibson	857-2125	2U-20	ISTL-ASD
498322	Alison Chaiken	Alison Chaiken	236-2231	2U-20	ISTL-ASD

(If more than four inventors, include additional information on another copy of this form and attach to this document)

Signature of Witness(es): *(Please try to obtain the signature of the person(s) to whom invention was first disclosed.)*

The invention was first explained to, and understood by, me (us) on this date: [APR. 14, 1995]

Full Name	Signature	Date of Signature
CHUNG CHING YANG	C C Yang	8/30/2000

Inventor & Home Address Information: *(If more than four inventors, include addl. information on a copy of this form & attach to this document)*

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Inventor's Full Name

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Description of Invention: *Please preserv[...] records of the invention and attach additional pag[...] [f]or the following. Each additional page should be signed and dated by the inventor(s) and witness(es).*

A. Prior solutions and their disadvantages (if available, attach copies of product literature, technical articles, patents, etc.).

In conventional rewriteable optical recording devices such as CD-RW and DVD-RW drives, bits are written by using lasers to reversibly change the optical reflectivity of a storage medium. The diffraction-limited spot size of the lasers sets a lower bound to the size of the bits that can be written. Currently, a number of groups are working to increase the areal storage density of optical recording devices by using near-field light sources. These near-field sources use evanescent light emitted through a small aperture to circumvent the diffraction limit. In a typical embodiment, light from a laser is emitted through an aperture (that has a diameter less than the wavelength of the light) at one end of the laser cavity. Alternatively, the light from a laser is coupled into a fiber optic cable. The end of the cable furthest from the laser tapers down to a small diameter and is coated with a metal. This coated, tapered fiber forms a waveguide for the laser light. The tapered end of the fiber contains a small hole (diameter< wavelength of the light) that constitutes a near-field light source. In these approaches, some of the near-field light that is incident on the storage medium is reflected back into the laser cavity through the small aperture in the laser or the fiber-optic cable. This reflected light causes a change in the output power of the laser that can be monitored to detect changes in reflectivity and, thereby, the presence of bits. A disadvantage to this bit detection technique is the tiny amount of light that is reflected back into the laser cavity and the correspondingly small changes to the output power of the laser. To read very small bits it is desirable to have a technique capable of producing larger signals (and a larger ratio of signal to noise). The present invention provides this technique.

It has also been proposed (patent # 5,557,596) that an electron beam can be used to read and write data on the surface of a diode. It is desirable to use low energy electrons in this technique so as to avoid problems with dielectric breakdown, field-emission from undesirable locations, and the need for relatively large and expensive power supplies. However, low energy electrons have very short penetration depths. Thus, if low energy electrons are used, this technique is highly susceptible to the condition of the surface of the storage medium. In many cases this has an adverse effect on the functioning of this technique. The present invention is capable of circumventing this problem.

The necessity of getting the low-energy electrons into the storage layer also limits device designs, in that only very thin la yers may be present on top of the storage media. Thus, an optically transparent conducting electrode could not be placed on top of the storage layer in an electron-beam-addressed memory, as an optically transparent electrode would still block electrons. If a conducting electrode on top of the storage area is desirable, it will in electron-beam-read back schemes limit the area of the device that can be used for storage. In addition, the stability and cyclability of a storage device using electron-readback may be limited by the mechanical and thermal properties of the free surface of the storage medium. Only very thin protective cladding layers can be used with the electron-beam-addressing scheme, as once again these layers would prevent access by low energy electrons.

B. Problems solved by the invention.

This invention addresses the small readback signals obtained in near-field optical recording devices from very small bits. It also addresses the issues caused by the short penetration depth of low energy electrons in the devices described in patent # 5,557,596.

C. Advantages of the invention over what has been done before.

The present invention gives larger readback signals in near-field optical recording devices. Also, it can make use of storage materials that don't necessarily exhibit large changes in reflectivity between their written and unwritten states. This new invention is not as susceptible to surface conditions as the devices described in patent # 5,557,596. It also has more design flexibility and possibly better robustness than the electron-beam readback devices described in patent # 5,557,596.

D. Description of the construction and operation of the invention (include appropriate schematic, block, & timing diagrams; drawings; samples; graphs; flowcharts; computer listings; test results; etc.)

1 In one embodiment, the storage medium is a diode. One layer of the diode is a material that can be changed between two or more states using a near-field optical source. We will call this the storage layer. The storage layer is in contact with another material or materials with which it forms a diode. The diode can be of any type that provides a built-in field for separating charge carriers. For example, the diode can be a pn-junction, pin-junction, or Schottky barrier depending on the material(s) used. A bit is written by locally altering the state of the storage layer with the aid of a near-field optical source. The different states of the storage material must be such that they provide a contrast in the bit detection ("read") mechanism described below. In one embodiment, the storage layer is a phase-change material similar to those currently used in optical recording. These materials can be reversibly changed from crystalline to amorphous by applying heat with the right temperature vs. time profile. The near-field optical source can be used for this purpose. The storage layer need not be a "phase-change" material, however. Any material that can be locally changed from one state to another state by means of a near-field optical source can be used. The near-field source need not operate in isolation to affect the transition from one state to another. It can also be used in conjunction with some other energy source. For example a resistive heater or applied electric field could be used to bias a large area of the storage medium while the near-field source locally affected a phase-change.

To read a bit, a near-field optical source is used to locally excite charge carriers in one of the layers of the diode. If carriers are excited in the storage layer, the number of carriers created (the "generation efficiency") will depend on the state of the storage layer in the region where photons

from the near-field source are incident. The [illegible]rs that determine the generation efficiency includ[illegible] band structure of the storage layer. Some fraction of the generated carriers of one sign (either electrons or holes) will be swept across the diode interface under the influence of the built-in field and any applied field. The current that results from carriers passing across the diode interface can be monitored to determine the state of the area on which the read photons are incident. The fraction of generated carriers that makes it across the diode interface (the "collection efficiency") is dependent upon the recombination rate in and around the area on which the read photons are incident, the effect of the bit on the built-in fields, etc. Thus, contrast in the current generated across the diode by the read photons can depend on both the local generation efficiency and the local collection efficiency. Both of these factors are influenced by the state of the region upon which the read photons are incident.

The generation and collection efficiency for carriers generated in the Layer Adjacent to the Storage Layer (LASL) can also be influenced by the presence of a bit in the neighboring storage area. Carriers can be generated in the LASL if it is the layer closest to the near-field source. Alternatively, carriers can be generated in the LASL, even if the storage layer is closest to the source, if the storage layer is sufficiently transparent to the read beam. In this case, the number of carriers generated in the LASL will depend on the number of read photons that make it through the storage layer. Thus, contrast in the read signal can be obtained by using the storage layer as a state-sensitive variable absorber. In this case, the storage layer may not itself form part of the diode structure. The transmission of this absorber can depend upon whether the beam is passing through a written or unwritten region. Alternatively, contrast in the generation rate of carriers in the LASL can arise due to differences in the electric field in the LASL due to the presence or absence of a bit in the neighboring storage layer. One way in which an electric field can influence the generation rate for free carriers is by reducing the geminate recombination rate. The collection efficiency for carriers generated in the LASL can be also be influenced by the presence or absence of a bit in the neighboring storage layer via changes in the electric field. In addition, this collection efficiency can be influenced by changes in recombination rate due to the presence or absence of a bit in the neighboring storage layer (e.g. an amorphous bit could locally increase the interface recombination velocity at the storage layer/LASL interface). Again, differences in the collection efficiency and/or generation efficiency of carriers created by the read beam provide contrast in the signal current generated across the diode.

It may be advantageous to cover the storage layer with a protective layer. During the write process, this protective layer could help to prevent chemical changes such as oxidation or thermomechanical changes such as bump or pit formation. It is possible that the LASL could serve as the protective layer as long as it is thin enough to allow writing of small bits. The protective layer may be merely a passivation layer, or it may be a conducting transparent electrode that is used to collect the photogenerated carriers.

The presence of electrodes on both the top and bottom surfaces of the storage layer and a possible LASL may offer advantages in device design. For example, uniform top and bottom electrodes will enhance the uniformity of the biasing field formed between the electrode and the storage layer. A back electrode could be present either on the side of the substrate opposite the optical sources (if a conducting substrate is used), or the back electrode could be on top of the substrate (if an electrically isolated substrate is used that provides mechanical support, but is not part of the electrical device *per se*. A top electrode could, in an optical access scheme, cover the entire top surface of the device.

It may be advantageous to cover the storage layer with a layer that enhances the thermal properties of the overall storage medium. E.g., if the storage layer is a phase-change material then it may be desirable for it to be in contact with a layer that aids in thermal quenching when trying to amorphize it. Alternatively or in conjunction with a cover layer it may be desirable to have a layer underneath the storage layer or LASL that improves thermal properties such as the ability to quench (and amorphize) the storage layer. An underlayer may also enhance the robustness of the device by preventing interdiffusion between the storage layer and the substrate material, or by discouraging delamination or dewetting of the storage layer (or LASL) from the substrate.

It may be advantageous to cover the storage layer with a layer that enhances optical properties such as an anti-reflection coating. For example, this could be used to increase the amount of light from the near field source that is absorbed in the storage layer or LASL. Alternatively, or in conjunction with a cover layer, a layer underneath the storage layer or LASL could be used to enhance the optical properties.

By monitoring the collection efficiency of a diode structure, it may be possible to control the separation of a plate containing the storage layer and diode structure from the optical sources. Alternatively, it may be possible to control this separation by monitoring the light reflected back into the near-field optical source, or by using a combination of both techniques. It may be advantageous to provide tracking and sector reference marks on the media layer surface by providing areas of contrasting reflectivity or diode collection efficiency.

When reading back signals from the media, it may be advantageous to use the near-field optical source in a constant flux mode, with the light source on steadily and the sampling window provided by translation or rotation of the media underneath the source. Alternatively, it might be preferable to pulse the optical source or otherwise modulate it in order to use a phase- and/or frequency-selective signal-to-noise enhancement technique in the diode signal amplifier electronics.

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